FOOD HABITS OF THE SPECIES OF THE GENUS *OLIGOPLITES* (CARANGIDAE) FROM THE CIENAGA GRANDE DE SANTA MARTA-COLOMBIAN CARIBBEAN

by

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ABSTRACT. - Four hundred and forty specimens of *Oligoplites saurus*, the leatherjack, and 104 of *O. palometa*, the Maracaibo leatherjack, were fished between May 1992 and April 1993 in the Ciénaga Grande de Santa Marta (Colombia), using gill nets and cast nets. Three methods of stomach content analysis were used: weight, numerical, and frequency of occurrence; they were combined to compare the Index of relative importance (IRI) of Pinkas *et al.* (1971). The IRI was calculated monthly and by size. Leatherjacks between 69 and 285 mm total length (TL) fed mainly on fishes and also on fish scales, crustaceans, insects, and other organisms, showing a high trophic plasticity. Their main item through the entire year was fishes; crustaceans, insects, and fish scales were main food items in two months. In the Maracaibo leatherjack sizes varied between 66 and 330 mm TL; juveniles fed on scales, complementing their diet with fishes, which become more important than scales with maturity. Scales and fishes were their main item during the entire year; crustaceans was a main item in two months. These species are third order consumers and their dietary overlap is intermediate.

RÉSUMÉ. - 440 spécimens d'*Oligoplites saurus*, le Sauteur cuir, et 104 d'*O. palometa*, le Sauteur palomette, ont été pêchés entre mai 1992 et avril 1993 dans le Ciénaga Grande de Santa Marta (Colombie), avec des filets maillants et des éperviers. Trois méthodes d'analyse de contenus stomacaux ont été utilisées: le poids, la numération et la fréquence d'occurrence des proies. Elles ont été combinées pour une comparaison avec l'Index d'Importance Relative (IRI) de Pinkas *et al.* (1971). L'IRI a été calculé par taille chaque mois. Les sauteurs cuirs entre 69 et 285 mm de longueur totale se nourrissent principalement de poissons mais aussi d'écailles de poisson, de crustacés, d'insectes et d'autres organismes, montrant une haute plasticité trophique. Les poissons constituent leur cible privilégiée durant toute l'année, les crustacés, les insectes et les écailles de poisson ne devenant leurs aliments principaux que pendant deux mois. La longueur totale des sauteurs palomettes capturés varie de 66 à 330 mm. Les juvéniles se nourrissent d'écailles, et de poissons comme ration complémentaire, qui devient plus importante que les écailles au fil de la maturation. Les écailles et les poissons constituent leur cible privilégiée durant toute l'année, les crustacés ne devenant leur aliment principal que pendant deux mois. Ces espèces sont des consommateurs de troisième niveau et le taux de recouvrement entre les régimes alimentaires des deux espèces est intermédiaire.

Key-words. - Carangidae, *Oligoplites*, ASW, Southern Caribbean, Colmbia, Coastal lagoons, Lepidophagy.

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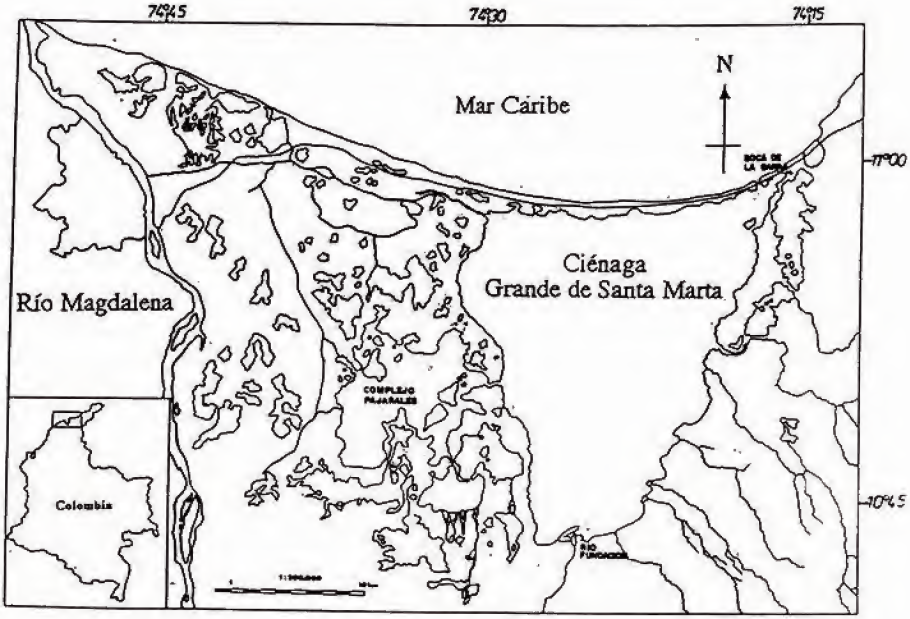

Fig. 1. - Study area: Ciénaga Grande de Santa Marta.

Tropical estuarine systems show habitat heterogenity which leads to high food availability for fishes; this is expressed in their wide array of trophic spectra (Yáñez-Arancibia *et al.*, 1985). Also, the food habits of fishes tend to change with age, habitat, season, and food availability (Yáñez-Arancibia and Nugent, 1977).

Carangids are active fish predators, widely distributed in tropical and temperate seas. Some easily enter fresh waters, but spawn pelagic eggs in the sea (Johnson, 1978). This family is highly important in Colombia in both number of species and economic value. The genus *Oligoplites* Gill includes five species restricted to the Eastern Pacific and the western Atlantic; only one, *O. saurus* (Bloch & Schneider, 1801), is found in both oceans. Most species are confined to coastal and neritic waters, and juveniles are sporadic invaders of coastal fresh waters (Smith-Vaniz and Staiger, 1973).

The leatherjack, *O. saurus*, reaches 285 mm fork length (FL) but rarely exceeds 250 mm (Johnson, 1978). It occurs in the western Atlantic from the Gulf of Maine to Montevideo, and in the Eastern Pacific from the Golfo de California to Islas Galápagos. Adults inhabit along sandy shorelines, inlets and bays. The Atlantic population is reported as *O. s. saurus*, while that from the American Pacific as *O. s. inornatus* (Gill). The Maracaibo leatherjack, *O. palometa* (Cuvier, 1833), grows to a maximum size of 400 mm FL and a weight of 0.9 kg, but sizes of 280 mm FL are common (Berry and Smith-Vaniz, 1978). It is distributed from Guatemala to São Paulo; it is pelagic, living mainly in brackish and fresh waters, over muddy bottoms, and between 18 and 45 m deep in the sea.

Sazima and Uieda (1980) stated that *O. saurus* seems to be more oportunistic than *O. palometa* since it eats a wider array of items; in any case, both species show scale eating behavior (lepidophagy) (Sazima, 1983). Santos-Martínez and Acero (1991) considered the leatherjack resident of the Ciénaga Grande de Santa Marta (CGSM), Colombia, but the Maracaibo leatherjack was classified as frequent visitor. Barrios (1981) presented

both species as piscivores at the CGSM. Castaño (1989), in research about the food habits of the CGSM's fishes, reported that the leatherjack diet was fishes in the dry season and fishes and insects in the rainy season; he concluded that it was a third order consumer. Lamprea (1990) found that juveniles of the leatherjack eat mainly polychaete worms, copepods and fishes. Our objective was to study the food habits of these two species, trying to infer if they compete for food resources.

Study area

The CGSM (10°41-59' N, 74°15-32' W), covering 450 km^2, is the largest Colombian coastal lagoon (Wiedemann, 1973), as well as one of the largest in South America (Fig. 1). It is located in the Caribbean coast within the deltaic plain of the Río Magdalena (Cosel, 1986). The CGSM is almost completely separated from the sea by a sand bar, Isla de Salamanca. Its only connection with the Caribbean is Boca de la Barra, a man-made canal with a maximum width of 300 m, located in the northeast portion of the lagoon (Wiedemann, 1973; Cosel, 1986). Marine waters, carried by tides and currents, enter the CGSM through this mouth and, after mixing with the fresh waters from rivers from the Sierra Nevada de Santa Marta and the Magdalena, generate salinities between 0 and 38 (Wiedemann, 1973). The North Colombian coast is located within the influence of the northeast trade winds. In the dry months, December to April, trade winds dominate in the lagoon, but from March to November, southwest winds carry rain to the whole region (Erffa, 1973).

METHODS

Forty eight field trips were made weekly between May 1992 and April 1993. To catch fish, two kinds of nets were used: a small cast net 3 cm mesh size and a gill net 2 cm mesh size. Specimens collected by fishermen were also kept; they usually use large cast nets and gill nets 7.6 cm mesh size. Fishes were injected in the gut with 10% formaline and were kept in a portable freezer with ice. Water samples were collected to determine salinity in the laboratory with an LF 191 conductimeter.

The stomach of each fish was dissected out, weighed (0.01 g precision) and the digestion of the contents determined following Laevastu (1980) as fresh, semidigested and digested. Finally, the contents were separated by food items, recording the number of each item and its wet weight (0.01 g precision). In order to quantify the contents, the recommendations of Windell and Bowen (1978) and Hyslop (1980) were followed.

The following indexes were used to evaluate the food habits of the study species:

Frequency percentage (% F) (Yáñez-Arancibia *et al.*, 1985):

$$\%F = \frac{n}{N} \times 100$$

where n = number of fishes eating any prey, and N = number of full stomachs examined.

Number percentage (% N) (Hureau, 1970):

$$\%N = \frac{Npe}{Npt} \times 100$$

where Npe = number of any prey or item, and Npt = total number of prey.

Weight percentage (% W) (Gherbi-Barré, 1983):

$$\% W = \frac{W}{WT} \times 100$$

where W = total weight of one prey, and TW = total weight of all prey.

Index of relative importance (IRI) (Pinkas *et al.*, 1971):

$$IRI = (\% N + \% W) \times \% F$$

IRI between 0 to 20 are incidental prey, 20 to 200 are secondary prey, and 200 to 20000 are main prey.

To determine the diet overlap between *O. saurus* and *O. palometa* the following indexes were used:

Schoener's index (S) (Daniels, 1982):

$$S = 100\left[1 - \tfrac{1}{2}\sum\left(P_{ij} - P_{ik}\right)\right]$$

where Pij = proportion of food item i in the species j, and Pik = proportion of food item i in the species k.

Horn's index (C) (Bray and Ebeling, 1975):

$$C = \frac{2\left(\sum_{i=1}^{s} P_{ij} P_{ik}\right)}{\sum_{i=1}^{s} P_{ij}^2 + \sum_{i=1}^{s} P_{ik}^2}$$

where s = total number of food categories, Pij and Pjk = proportions in the total diet of the species Pj and Pk, taken from a given category of food i.

S and C vary between 0 (no overlap) and 1 (total overlap); trophic spectra are considered significantly similar when S or C $\geq$ 0.6.

RESULTS

A total of 544 specimens was collected and analyzed during the twelve months of sampling: 440 were *Oligoplites saurus* between 69 and 285 mm TL, and 104 were *O. palometa* 66-330 mm TL. Both species were found in waters with salinities between 4.9 and 38.4.

Oligoplites saurus

Of the 440 stomachs studied, 64% contained some kind of food. Of those 282 stomach contents, 5% were fresh, 41% semidigested and 54% digested. Food items were identified to the lowest possible taxonomic rank; 18 kinds of food were found, which were grouped in five trophic levels or main items:

Fishes. - Includes prey of the families Engraulidae (31%), Mugilidae (2%), Gerreidae (1%), Poeciliidae (1%), and unidentified, highly digested, fish remains (65%).

Crustaceans. - Includes shrimps of the family Penaeidae (47%), zoeas (15%), megalopas (15%), and unidentified pieces of crustacean exoskeletons (23%).

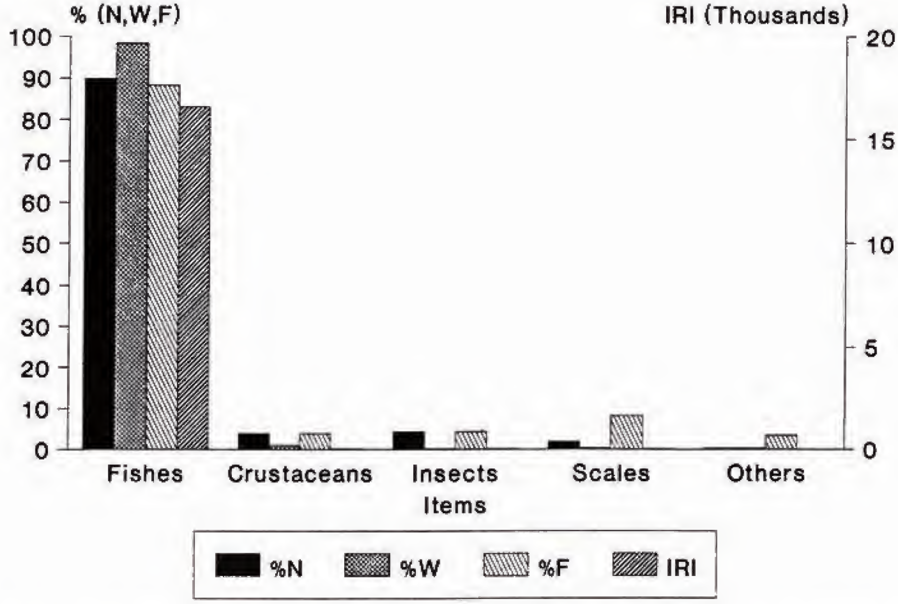

Fig. 2. - Food indexes of *Oligoplites saurus* (% N = percentage in number, % W = percentage in weight, % F = percentage in frequency, IRI = index of relative importance).

Insects. - Two orders were identified, hymenopterans (62%) and dipterans (38%). Since those prey were well digested (except some wings) it was impossible to attempt a more complete identification.

Scales. - This item was not grouped with fishes due to the lepidophagic behavior of this species. Only small, unidentified scales were found.

Others. - Includes low frequency items, such as anemones (22%), polychaetes (22%), remains of mytillid molluscs (11%), nematodes (11%), and plant remains (33%).

According to the percentages in number, weight, and frequency, fishes were the most important items for this species; the other items show low values (Fig. 2). Using the IRI, fishes was also the most important item and the other items were considered accidental (Fig. 2).

The main item through the entire year was also fishes (Table I). Crustaceans was a major food item in June and October, a secondary one in May and March, and an incidental item in February. Insects appeared in stomachs in six of the twelve months, and was considered a main item in August and March, a secondary item in October and April, and an incidental one in May and December. Scales were found almost all year round, being a main item in August and January, a secondary item in July, October, February and April, and an incidental one in December and March.

At any size the main food item of the leatherjack was again fishes, but in the specimens below 100 mm TL scales and crustaceans were also considered main items and other items were absent (Table I). In specimens 101-200 mm TL any item but fishes was incidental. For those larger than 201 mm TL insects were secondary, and the remaining items were considered incidental.

Table I. - Indexes of relative importance (IRI) by month and by size for both species (N° = number of stomachs with food, S = salinity month average).

	Oligoplites saurus						*Oligoplites palometa*				
Months	**N°**	**Fishes**	**Scales**	**Crustaceans**	**Insects**	**Others**	**N°**	**Fishes**	**Scales**	**Crustaceans**	**S**
May 1992	35	15933	0.000	183.237	11.174	0.000	3	15617	1461	0.000	31.5
June	3	13696	0.000	2101.179	0.000	0.000	3	10172	3171	104.966	26.2
July	29	18293	108.923	0.000	0.000	0.000	5	1677	7566	1278.440	24.3
August	12	6546	605.227	0.000	1394.128	0.000	6	4749	7001	0.000	21.7
September	5	20000	0.000	0.000	0.000	0.000	8	3148	13704	0.000	19.6
October	10	9059	147.850	3087.200	61.700	12.050	21	1209	8385	1431.957	18.5
November	3	20000	0.000	0.000	0.000	0.000	-	-	-	-	20.0
December	35	17072	0.374	0.000	0.251	5.143	2	4246	11507	0.000	22.1
January 1993	8	18504	374.000	0.000	0.000	0.000	3	3125	10208	0.000	24.5
February	27	17041	98.910	11.764	0.000	2.415	10	8636	2761	0.000	27.6
March	71	12568	9.040	54.219	220.260	10.126	13	8141	6020	0.000	31.4
April	44	15537	121.147	0.000	30.788	0.000	11	4254	6655	0.000	32.8
Size (mm)											
< 100	27	9152	519.032	402.245	0.000	0.000	12	466	9017	431.774	
101 - 200	135	17442	14.098	18.309	5.234	2.760	10	2444	12501	0.000	
201 - 300	120	16519	7.115	7.399	42.785	0.790	60	5979	6473	78.309	
> 300	-	-	-	-	-	-	3	20000	0	0.000	

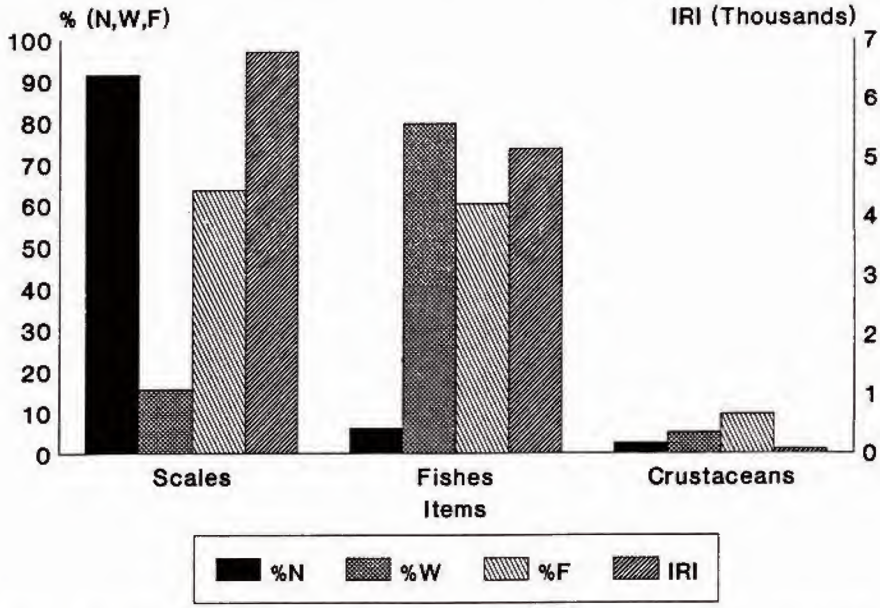

Fig. 3. - Food indexes of *Oligoplites palometa* (% N = percentage in number, % W = percentage in weight, % F = percentage in frequency, IRI = index of relative importance).

Oligoplites palometa

Of the 104 stomachs studied, 82% had some kind of food. Of those 85 stomach contents, 7% were fresh, 54% semidigested, and 39% digested. A total of ten different prey types was found, which were grouped in three trophic categories or main items.

Fishes. - Includes prey of the families Engraulidae (38%), Ariidae (14%), Mugilidae (7%), Poeciliidae (3%), and highly digested, unidentified fish remains (40%).

Crustaceans. - Includes shrimps of the family Penaeidae (34%), zoeas (33%), and megalopas (33%).

Scales. - Large unidentified scales were found.

The percentage in number for this species ranks the scales higher in importance than fishes, but the percentage in weight ranks fishes over scales (Fig. 3). The frequency percentage tends to equal fishes and scales. Using any percentage, crustaceans show low values.

Using the IRI, scales and fishes were the main item during the entire year, but scales ranked higher than fishes almost all months (Table I). Crustaceans appeared as a main item in July and October, and as a secondary item in June.

For specimens below 300 mm TL the main items were scales and fishes, but those larger than 301 mm included only fishes (Table I). For specimens below 100 mm crustaceans were also a main item, but were absent from Maracaibo leatherjacks between 101 and 200 mm, and appeared as secondary item for specimens between 201 and 300 mm.

Diet overlap

To calculate the index of overlap, the IRI of the common trophic categories were used. S presented a value of 0.43 and C a value of 0.57. Therefore diet overlap is considered intermediate.

DISCUSSION

The existence of several methods for studying gastric contents in fishes is an indication that no method alone can interpret fully the importance of dietary components; it is also clear that the method used must correspond closely to the habits of the studied fish (Silva and Stuardo, 1985). Since each method shows an item as important according to the attribute that it is designed to measure, different information is obtained about the value of any dietary item if the percentages in number, weight, and frequency are analyzed separately (Hyslop, 1980). Silva and Stuardo (1985), who compared different methods to identify the relative importance of the food items in fishes, concluded that the IRI is most proper for fishes eating heterogeneous prey. Therefore, in order to corroborate if the diets of the studied species adjust to what may be expected from lepidophagic fishes (Carr and Adams, 1972; Major, 1973; Sazima and Uieda, 1980; Lucas and Benkert, 1983; Sazima, 1983; Leite and Jégu, 1990), the percentages were combined in the IRI.

Lepidophagy is considered a form of predation, even if the predator species complements its diet with items of animal or vegetable origin (Sazima and Uieda, 1980). In the Maracaibo leatherjack scales were not only important but they were eaten in high proportions up to larger fish sizes (272 mm TL); on the other hand, the leatherjack eats scales over a narrower body size range (85-242 mm TL). This agrees with Sazima and Uieda (1980), who concluded that *Oligoplites palometa* is more lepidophagic than other *Oligoplites* and eats scales up to 190 mm FL, while *O.saurus* eats scales only up to 87 mm FL. Other authors reported the leatherjack as eating scales between 26 and 60 mm SL (Carr and Adams, 1972), between 102 to 139 mm SL (Major, 1973), and between 26 and 40 mm SL (Lucas and Benkert, 1983).

Scale eating fishes exhibit several morphological adaptations, mainly in form, position and size of teeth, allowing them to exploit better this trophic resource (Sazima and Uieda, 1980; Sazima, 1983; Leite and Jégu, 1990). *Oligoplites* species have two types of teeth during their ontogeny: juveniles present two narrowly separated rows of curved and spatulated teeth which are replaced in adults by widely spaced rows of more straight and robust teeth (Smith-Vaniz and Staiger, 1973). These dentition changes begin at 50 mm SL and are complete at about 150 mm, when the fish begins to be totally carnivorous (Major, 1973). According to all of this, lepidophagy in the Maracaibo leatherjack at larger sizes than in the leatherjack might be due to its larger size and average maturity length (Duque-Nivia *et al.*, 1995).

No known fish species is able to survive only from materials coming from cleaning behavior (Carr and Adams, 1972); cleaning fishes are also known to feed on scales and parasites. Carr and Adams (1972) suggested that the alimentary importance of the cleaning behavior of juvenile leatherjack comes from eating skin, meat, and ectoparasites together with the scales. Major (1983) pointed out that the scales and epidermal tissue are the main source of food, and rejected the importance of mucus, which was highlighted by Springer and Smith-Vaniz (1972).

Breder (1942) observed leatherjacks 27-34 mm SL floating, usually head down, near the water surface, resembling leaves. Lucas and Benkert (1983) reported that after the leaf imitating position, the juveniles of this species swim following a passing fish and begin feeding on scales and ectoparasites. Sazima and Uieda (1980) discussed the fact that fishes of the genus *Oligoplites* have specialized and deeply embedded acicular scales and suggested that this is related to lepidophagy, representing an adaptation against intraspecific and interspecific attacks.

In the CGSM the leatherjack feeds mainly on fishes, without showing any important ontogenetic or seasonal dietary shift, and presents a strong trophic plasticity when this resource diminishes. The Maracaibo leatherjack, on the other hand, feeds mainly on scales and fishes. Several authors (Osorio, 1988; Castaño, 1989; Arenas and Acero, 1990; Cataño and Garzon-Ferreira, 1994) have discussed seasonal dietary shifts in the fish fauna of the CGSM, presenting them mainly as consequences of the variations on prey availability, which depends upon salinity changes. The index of diet overlap suggests an intermediate level of food competition between *O. saurus* and *O. palometa*. In any case, even the more precise measures of overlap do not show the biological significance of the results. It is possible that fishes of different species or populations eat the same kind of food at the same place but at different hours, so they never meet, or that such food might be so abundant that competition would be strongly reduced (Prejs and Colomine, 1981).

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